68-109

DEPARTMENT OF THE INTERIOR
UNITED STATES
GEOLOGICAL SURVEY

Preliminary report on the engineering geology of the Boulder quadrangle, Boulder County, Colorado

OPEN FILE - 1968
Sheet 5 of 5 sheets

Generalized description of engineering geologic aspects of igneous and metamorphic bedrock in the Boulder quadrangle, Colorado

Engineering geology unit name and map symbol	Equivalent geologic unit (s)	Description and thickness	Other features	Topographic form and surface relief	Weathering and ancient soils	Workability	Surface drainage and erosion	Ground water	Suitability for waste disposal	Foundation stability	Slope stability	Probable earthquake stability	Use
Biotitic gneiss bg	Biotitic gneiss	Mica-rich metamorphic rock, in part finely interlayered with discontinuous quartz and feldspar bands or pods of igneous origin. Gneiss very hard, brittle; gray to dark gray; fine grained; chiefly quartz, feldspar, and black mica (biotite); characterized by metamorphic layering (foliation). Foliation results from segregation of biotite from quartz and feldspar into dark platy and light grainy layers during metamorphism; generally planar, locally folded and crumpled. Rock breaks most easily parallel to biotite plates or foliation. May extend indefinitely in depth.	Includes some bodies of Granite (gt) and Pegmatite and aplite (pa) too small to map individually. Joints conspicuous; generally open within 300 ft of surface; pattern blocky to seamy; as many as three distinct mutually perpendicular sets; major set subparallel to metamorphic layering (foliation), spaced unevenly 2 in.-4 ft apart, commonly strike northeast-southwest, dip as low as 45° in part inclined northwest, in part southeast, vertical in places. Bulk density 2.7-2.8.	Rugged, rolling hills and low mountains.	Deeply weathered locally on hilltops and ridges, weathered zone typically composed of two subzones. Upper, rock decomposed; medium to very dense iron-oxide-stained yellowish-brown clayey sand and gravel: (SC, GC[1]); as much as 10 ft thick. Lower subzone, moderately weathered; grades from heavily iron-oxide-stained and moderately fractured rock downward into unweathered rock; base very uneven; commonly subzone several tens of feet thick extending downward along major fractures; thinner in areas between fractures. Outcrops in uplands, weathered and etched by erosion; commonly rusty-brown to rusty-gray angular-shaped masses; along canyons and stream valleys relatively unweathered.	Excavation: very difficult in unweathered rock, generally requires blasting. Moderately easy to moderately difficult in weathered rock; can be excavated with rippers and scrapers, locally with front-end loaders. Compaction: very difficult if unweathered, requires heavy shovels and dozers for grading. Drilling: very difficult.	Infiltration: usually slow, chiefly into fractures. Runoff: generally moderate. Susceptibility to erosion: highly resistant.	Permeability: high near surface, especially in joint set subparallel to metamorphic layering (foliation); decreases at depth; very low at depth of about 300 ft. Water table: varies locally, depends on openness and continuity of joints. Yield to wells: very small quantities, probably 0-3 gpm; higher in fractured zones. Quality: usually moderately hard to hard. Use: reported poor source for domestic use; fair to good source for stock water.	Septic systems: generally unsatisfactory except locally where decomposed rock in weathered zone is thick enough for proper burial of system; percolation generally satisfactory where rock decomposed, locally marginal. Risk great of pollution passing through major fracture into water supplies. Dump sites: generally unsuitable because access difficult, excavation very difficult, and risk great of ground-water pollution.	Excellent in unweathered rock; good locally where decomposed.	Varies, good to hazardous. Risk moderate of rockfalls and small debris slides along steep slopes of valleys; inspection upslope from building sites recommended. Safe angle of cut slopes locally controlled by orientation of metamorphic layering (foliation) and major joints and by regularity of joints. Hazardous if inclined joints undercut, particularly those joints subparallel to foliation. Highway back-slopes cut 1/4 horizontal to 1 vertical and steeper common.	Excellent where rockfall and debris slide hazards absent.	Possible local source of fair-quality crushed aggregate; fair-quality riprap.
Granite gt	Boulder Creek Granite Silver Plume Granite Quartz monzonite Alkali syenite Quartz latite porphyry Bostonite porphyry Diorite	Quartz-feldspar-rich igneous rock, very hard, tough, light gray or pale reddish brown; includes abundant black mica (biotite) or white mica (muscovite) in small aggregates and some hornblende. Grains generally 1/32-1/4 in. size; interlocking. Rock generally massive but some subparallel orientation of mica plates hints of crude metamorphic layering (foliation); rock probably breaks most easily along subparallel direction. May extend indefinitely in depth.	Includes some light-colored dike rocks which cut sedimentary as well as metamorphic and other igneous rocks. Joints conspicuous; generally open and smooth-walled near ground surface, close at depth, commonly tight at 200 ft below surface; lack apparent relationship to crude metamorphic layering (foliation); grouped in as many as three distinct mutually perpendicular sets and form blocky pattern; spaced unevenly tens of feet apart. In dikes, joints more closely spaced and in random sets. Bulk density 2.6-2.7.	Gently rolling hills to low mountains; locally very rugged, especially near streams.	Deeply weathered on hilltops and ridges, weathered zone typically composed of three subzones. Uppermost, rock decomposed; dense to very dense iron-oxide-stained orange-brown silty to clayey sand and gravel: (SM, GM, SC, GC[1]); 10-15 ft thick. Intermediate subzone, partly decomposed chiefly very dense locally dense iron-oxide-stained yellowish brown moderately fractured unevenly weathered; as much as 10 ft thick. Lowermost subzone, slightly weathered; iron-oxide-stained yellowish gray slightly fractured. Total thickness of weathered zone commonly as much as 50 ft; thickest along major fractures; thinner in areas between fractures; grades unevenly into unweathered rock. Outcrops in uplands, weathered and etched by erosion; chiefly rusty-black-speckled spheroidal masses; along canyons and stream valleys relatively unweathered. An ancient weathered profile 40-80 ft thick and characterized by three subzones comparable to those above, generally underlies and commonly is mistaken for "Conglomerate and siltstone (cgl-ms)."	Excavation: very difficult, generally requires blasting; decomposed uppermost subzone can be excavated with front-end loaders; upper part of weathered intermediate subzone commonly can be excavated with heavy rippers and scrapers. Compaction: very difficult in fresh rock; moderately easy in decomposed rock: similar to "Silty bouldery sand and gravel (Smb)." Drilling: generally difficult; moderately easy to moderately difficult in weathered zone.	Infiltration: generally moderate, chiefly into weathered zone and fractures. Runoff: varies moderate to slow depending chiefly on presence and extent of weathered zone. Susceptibility to erosion: generally highly resistant; upper part of weathered zone same as "Silty bouldery sand and gravel (Smb)."	Permeability: high in joints and fractures near surface; decreases at depth; very low at depth of about 200 ft. Water table: varies locally, depends on openness and continuity of joints and fractures. Yield to wells: reportedly 0-5 gpm; as much as 25 gpm in fractured zones. Quality: hard; iron content high. Use: reportedly poor to fair source for domestic use; fair to good source for stock water.	Septic systems: generally satisfactory where rock decomposed; percolation generally satisfactory, locally may range from too fast to marginal. Other parts of weathered zone and unweathered rock unsatisfactory where decomposed rock thick enough for proper burial of system, and rock lacks sufficient fracturing. Risk great of pollution passing through major fractures into water supplies. Dump sites: generally poor where decomposed because risk great of ground-water pollution and commonly because access difficult and excavation very difficult. Unsuitable where slightly weathered to unweathered.	Excellent in unweathered rock; good where decomposed.	Varies, mostly good to excellent, locally hazardous. Risk moderate to slight of rockfalls and small debris slides along steep-walled canyons. Safe angle of cut slope locally controlled chiefly by orientation of major joints. Highway back-slopes cut vertical common.	Same as for above.	Source of decomposed granite for road metal; some unweathered granite locally suitable for fair- to good-quality riprap.
Pegmatite and aplite pa	Pegmatite and aplite	Quartz-feldspar-rich igneous rock in thin tabular dikes and large irregular bodies; very hard, commonly brittle. In part very light colored; grains very coarse, with some a few inches long; interlocking; nonoriented. In part pale reddish brown; grains fine giving sugary appearance; interlocking; nonoriented. Dikes generally 1-30 ft thick; some curved; extent in depth unknown. Irregular bodies as much as 1,500 ft wide; extent in depth unknown.	Aplite dikes generally longer, narrower than pegmatite dikes. Joints usually inconspicuous, incipient to very poorly formed, tight. Margins of pegmatite dikes commonly highly fractured; fractures open. Bulk density 2.65-2.75.	Dikes commonly form low ridges which protrude a few feet above surrounding terrain.	Hairline fractures near surface; no weathering products.	Excavation: very difficult, requires blasting. Compaction: very difficult, requires heavy shovels and dozers for grading. Drilling: very difficult.	Infiltration: negligible to slow, chiefly into fractures. Runoff: rapid because of slope and lack of infiltration. Susceptibility to erosion: very resistant.	Permeability: negligible to low; locally high near margins where moderately fractured. Water table: varies locally, depends on openness and continuity of joints. Yield to wells: varies locally as above. Quality: hard; iron content high. Use: estimated locally poor to good source for domestic use and stock water.	Septic systems: unsatisfactory because percolation probably too slow and cover lacking for proper burial of system. Risk moderate of pollution passing through major fracture into water supply. Dump sites: unsuitable chiefly because excavation very difficult, access difficult.	Excellent.	Same as for above.	Same as for above.	Source of crushed aggregate, white quartz for decorative landscaping.
Dark heavy rock db	Diabase Hornblende-biotite lamprophyre Biotitic amphibolite	Hornblende-feldspar-rich igneous rock in thin tabular dikes; hard to very hard, tough, dark to very dark gray; scattered grains as much as 1/4 in. size in groundmass; grains and groundmass interlocking; generally nonoriented. Dikes 1-30 ft thick; some curved; extent in depth unknown; contacts abrupt. Unit includes two small irregular masses of biotite-hornblende-rich metamorphic rock; very hard, very tough, very dark gray; grains generally less than 1/32 in. size; subparallel oriented; streaked with thin white lenses and pods of quartz and feldspar. Irregular masses as much as 300 ft wide; extent in depth unknown.	Fractures conspicuous, spacing commonly about 1 ft, irregular; pattern seamy to blocky. Biotitic amphibolite breaks most easily subparallel to metamorphic layering (foliation). Bulk density commonly 2.8-3.0.	Generally inconspicuous; may underlie small gullies and small saddles in ridges.	Upper 1-3 ft probably altered in places, commonly stained reddish brown by iron oxide.	Excavation: very difficult, requires blasting. Compaction: very difficult, requires heavy shovels and dozers for grading. Drilling: very difficult.	Infiltration: probably slow, chiefly into fractures. Runoff: fast because of slope and slow infiltration. Susceptibility to erosion: moderately to very resistant.	Specific properties unknown.	Septic systems: Same as for above. Dump sites: Same.	Excellent.	Same as for above.	Same as for above.	Possible source of aggregate and riprap with high specific gravity, toughness.
Thoroughly fractured rock fr	Shear zone(s)	Crushed and brecciated rock, composed originally of any of the map units listed above, generally in tabular to irregular bodies of varying thickness and size. In part simply fractured, in part finely crushed, in part altered to clayey sand, locally recrystallized to very hard, brittle rock known as breccia reef. Bodies of fractured rock generally less than 300 ft wide; maximum width 1,000 ft; extent in depth unknown.	Fractures appear unrelated to metamorphic layering (foliation) or jointing in adjacent rock; boundaries gradational over tens of feet into undeformed rock; thoroughly fractured rock also locally grades into enclosed bodies of undeformed rock. Dip of unit commonly vertical to near vertical.	Generally underlies streams, gullies, and saddles in ridges; in places forms long prominent ledges called breccia reefs as much as 20 ft wide and 30 ft high.	Generally deeply weathered, particularly on hilltops and ridges, commonly decomposed; dense to very dense iron-oxide-stained orange-brown silty to clayey sand and gravel; (SM, GM, SC, GC[1]); extent in depth unknown; products of alteration resulting from weathering and deformation similar.	Excavation: varies locally; very difficult in recrystallized parts: requires blasting; moderately easy in deeply weathered areas: commonly excavated with front-end loaders. Compaction: varies locally; moderately easy where altered to sand and if boulders removed. Drilling: varies locally; very difficult in recrystallized parts; moderately difficult where thoroughly fractured and altered.	Infiltration: moderate, except where recrystallized. Runoff: generally moderate, locally rapid. Susceptibility to erosion: mostly slight, by gully wash and stream scour; recrystallized so-called breccia reefs very resistant.	Permeability: varies greatly, depends chiefly on intensity of fracturing and presence of clay; maximum permeability in parts of zones having fractures spaced 1-6 in. apart. Water table: varies locally, depends chiefly on intensity of fracturing and presence of clay. Yield to wells: reportedly as much as 30 gpm, probably varies greatly. Quality: hard; iron content high. Use: estimated poor to excellent source for domestic use and stock water.	Septic systems: varies. Commonly satisfactory where decomposed and finely crushed; percolation generally satisfactory. Locally unsatisfactory where fractured and excavation difficult and where recrystallized. Risk great of pollution passing through unit into local water supplies. Dump sites: generally poor chiefly because risk great of ground-water pollution.	Varies; good to fair depends chiefly on recrystallization and thoroughness of weathering.	Varies, fair to hazardous. Risk great of debris slides and rockfalls along steep slopes of valleys; stability investigations for large open excavations recommended. State regulations require support or 45° repose in excavations.	Good in recrystallized rock to poor in thoroughly fractured and decomposed rock. No known evidence of movement by rock faulting in unit for at least 12 million years, suggests that possibility extremely remote for renewed movement.	Source of decomposed rock for road metal.

1/Unified Soil Classification (U.S. Army Corps Engineers, 1953).